CLAIMS

What is claimed is:

1. A micromirror for directing a beam of light, the micromirror comprising:

a mirror plate movably coupled to a substrate, the mirror plate having a reflective upper surface; and

a lower reinforcement rib coupled to a lower surface of the mirror plate, wherein the lower reinforcement rib is formed in a rib trench within the substrate when at least a portion of the mirror plate is formed, and wherein the lower reinforcement rib reinforces the mirror plate to minimize mirror plate curvature.

2. The micromirror of claim 1, wherein the mirror plate is coupled to the substrate with at least one vertical comb drive electrostatic actuator.

3. The micromirror of claim 1, wherein the substrate comprises a portion of a silicon wafer.

4. The micromirror of claim 1, wherein the rib trench within the substrate has one of an angled sidewall or a vertical sidewall.

5. The micromirror of claim 1, wherein the lower reinforcement rib is filled when the lower reinforcement rib is formed in the rib trench.

6. The micromirror of claim 1, wherein the lower reinforcement rib and the substrate are separated by removing a first sacrificial material disposed between the lower reinforcement rib and the rib trench when the lower reinforcement rib is formed.

7. The micromirror of claim 1, wherein the lower reinforcement rib is peripheral to an optical surface of the mirror plate.

8. The micromirror of claim 1, wherein the lower reinforcement rib is located under an optical surface of the mirror plate.

9. The micromirror of claim 1, wherein the lower reinforcement rib comprises at least one reinforcement ring near the periphery of the mirror plate.

10. The micromirror of claim 1, wherein the lower reinforcement rib comprises a plurality of reinforcement rings, hexagonal cells, or radial members.

11. The micromirror of claim 1, wherein the mirror plate is planarized.

12. The micromirror of claim 1, wherein the mirror plate comprises a first structural layer and a second structural layer, the second structural layer coupled to the first structural with at least one filled via.

13. The micromirror of claim 1 further comprising:

a mirror metal disposed on the upper surface of the mirror plate.

14. The micromirror of claim 13, wherein the mirror metal comprises an alloy of aluminum, copper and silicon.

15. The micromirror of claim 1 further comprising:

an upper reinforcement rib disposed on the upper surface of the mirror plate, wherein the upper reinforcement rib cooperates with the lower reinforcement rib to reinforce the mirror plate.

16. A system for directing a beam of light, the system comprising:

a plurality of micromirrors movably coupled to a substrate,

wherein each micromirror includes a mirror plate having a reflective upper surface and a lower reinforcement rib coupled to a lower surface of each mirror plate, and

wherein the lower reinforcement rib is formed in a rib trench within the substrate when at least a portion of the mirror plate is formed, and

wherein the lower reinforcement rib reinforces the mirror plate to minimize mirror plate curvature.

17. The system of claim 16, wherein each mirror plate is coupled to the substrate with at least one vertical comb drive electrostatic actuator.

18. The system of claim 16, wherein each mirror plate comprises a first structural layer and a second structural layer, the second structural layer coupled to the first structural layer with at least one filled via.

19. The system of claim 16 further comprising:

a mirror metal disposed on the upper surface of each mirror plate.

20. The system of claim 16 further comprising:

an upper reinforcement rib disposed on the upper surface of each mirror plate.

21. A method of fabricating a reinforced micromirror, the method comprising:

etching a rib trench into a surface of a substrate;

depositing a first sacrificial layer in the rib trench and on the surface of the substrate;

depositing a first structural layer on the first sacrificial layer;

etching the first structural layer to form at least a portion of a mirror plate; and

removing the first sacrificial layer to separate the mirror plate and the lower reinforcement rib from the substrate, wherein the separated lower reinforcement rib reinforces the mirror plate to minimize mirror plate curvature.

22. The method of claim 21 wherein the etched rib trench comprises one of an angled sidewall or a vertical sidewall.

23. The method of claim 21 wherein the first sacrificial layer comprises one of a deposited oxide or a thermal oxide.

24. The method of claim 21 further comprising:

planarizing the first structural layer after depositing the first structural layer.

25. The method of claim 21 further comprising:

depositing a second sacrificial layer on the first structural layer;

etching the second sacrificial layer to form at least one via hole in the second sacrificial layer;

depositing a second structural layer on the second sacrificial layer;

etching the second structural layer to form the mirror plate; and

removing the second sacrificial layer, wherein the second structural layer is coupled to the first structural layer with at least one filled via.

26. The method of claim 25 further comprising:

planarizing the deposited second sacrificial layer prior to depositing the second structural layer.

27. The method of claim 21 further comprising:

depositing a mirror metal on an upper surface of the mirror plate.

28. The method of claim 27 wherein the deposited mirror metal comprises an alloy of aluminum, copper and silicon.

29. The method of claim 21 further comprising:

plating an upper reinforcement rib on the upper surface of the mirror plate, wherein the upper reinforcement rib cooperates with the lower reinforcement rib to reinforce the mirror plate.